HOHENHEIMER DISKUSSIONSBEITRÄGE

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Nr. 257/2005

Institut für Volkswirtschaftslehre (520)

Universität Hohenheim, 70593 Stuttgart

ISSN 0930-8334

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July 28, 2005

Abstract

This study develops innovative measures of openness towards bilateral trade. The most widely applied openness indices are not able to accurately calculate the degree of trade openness. For example, the intra-regional export ratio which relates the value of exports of an integration area to the gross domestic product, can exceed 100 percent because trade is stated in gross terms, while the gross domestic product is expressed in value-added terms. This implies a negative value of domestic non-tradeables. The actual openness concept corrects the traditional concept by expressing trade in value-added terms instead of gross terms.

JEL classification: C67, E20, F15, F42

Keywords: Degree of openness, Openness to intra-regional trade, Bilateral trade, Value-added approach, Input-output analysis

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1. Introduction

The *degree of openness to trade* indicates the importance of international trade linkages for a country. Importance refers to the power that trading partners abroad have to influence the operation of a market economy. Tighter connections between domestic and foreign markets can reduce the effectiveness of demand stimulation by fiscal and monetary policies. For example, increased spending by domestic consumers might be directed at foreign firms. In addition, external factors can exert greater influence on domestic outcomes. For example, increased product-market competition might affect production output, income, employment, or price level of the domestic economy. A value of zero for the degree of openness indicates that the country is a closed economy in total autarky. The higher the level of openness, the more likely it is that the foreign countries have a stronger affect on the economic variables of the home country.

In this contribution, the economic role of the member states of an integration area, such as the European Union, is accentuated for a country and thus the bilateral trade flows are emphasized. The focus of a country on a group of trading partners is of interest, for example, if the country decides whether it should join a fixed exchange rate area or not (McKinnon 1963; Mundell 1961). Net benefits of pegging a country's currency to the region are largely determined by the country's level of exchange of trade with the members of the integration area. In this study, the term *degree of openness to intra-regional trade* is used to demarcate the significance of trading partners within an integration area from all foreign countries.

Shares of trade represent the traditional outcome-based concept for calculating a country's degree of openness. They have a dominant role as proxies of openness in the empirical literature and are the source for the development of innovative indicators in this article, which adjust the conventional indices. Trade shares show the value of traded goods and services in

relation to a country's gross domestic product (GDP), the value of all final goods and services produced by its factors of production.

According to Kotcherlakota and Sack-Rittenhouse (2000), trade shares at the export side express a country's surplus production. Its households consume, the government purchases, firms invest, and foreign residents buy the country's final goods and services produced by domestic factors of production and imported intermediate products. If foreign countries demand final goods and services, then those can no longer be sold on the home market. The openness measure *intra-regional export ratio* (IER) relates the value of goods and services, sold by the country to member states of an integration area, to the value of all goods and services produced by domestic factors of production for domestic and foreign expenditure (GDP) for the period of one year and expressed as a percentage. A value of zero percent for the intra-regional export ratio means that only domestic spending exists. The more open an economy is, the more the country is able to create a surplus production.

In addition, the *intra-regional import ratio* (IIR) index calculates a value which represents the importance of trade linkages for an economy with an integration area from the import side by emphasizing the value of the country's imports from the region as share of the national income (GDP). Kotcherlakota and Sack-Rittenhouse (2000) interpret this type of measure of openness as the dependency of a country's residents on imported commodities and services. In the case of a value of zero percent, the intra-regional import ratio indicates that domestic residents demand only domestic goods and services whereas a more open country becomes more dependent on foreign goods and services.

Despite the concept of trade openness being conceptually simple, many approaches of empirically measuring openness have been developed. There is *no widely accepted proxy* of openness because no index provides a perfect or unambiguous indication of the importance of international trade – neither in the comparison of the extent of trade integration across countries

at one point in time nor for the judgment of the present trade flows of a country against its historical development. Falvey and Gemmell (1999) point out that numerous different openness measures are employed because their corresponding rankings of openness are not strongly correlated and no index is obviously superior over other concepts. Wacziarg (2000) proposes *combining several measures* of openness since using a variety of indices may indicate different aspects of a country's trade openness. For example, Chen (1999) applies an array of five measures of openness, Spilimbergo et al. (1999) use seven different indices, and Edwards (1998) employs nine alternative indicators. This approach might provide a richer picture of the degree of openness compared to applying only one single measure, particularly in cases where the estimated coefficients of the proxies of openness perform as they were expected to and are statistically significant. Furthermore, it can be tested whether results are sensitive to the use of a particular index.

Lloyd and MacLaren (1998) emphasize the construction of *summary measures* of openness as an alternative approach to the employment of an array of several indices. The main drawback of such indicators is the problem of constructing an appropriate system of weighting that avoids aggregation biases. In both cases – the use of different measures or a single summary index – the difficulty of selecting the suitable proxies is not solved, otherwise a superior single concept of openness would be employable for empirical research.

Shares of trade are made up of a series of factors, such as comparative advantage, geographic variables, and economic policy. Since trade shares include all these determinants of trade and, thus, measure a country's actual exposure to trade interactions, trade shares may account quite well for the effective level of international market integration (see, for example, Wacziarg 2000). This feature of traditional measures of openness is also the central criticism. Shares of trade are endogenous to variables being modeled. Trade and output could be driven by some common factors, such as human capital investments. These endogeneity problems with re-

spect to growth are emphasized by Söderbom and Teal (2001) and Frankel and Romer (1999) among others. In addition, trade shares do not relate to theories which link trade, for instance, to growth. Such a theory could emphasize the role of imports in the process of growth. Developing countries might benefit due to imports of capital, intermediate commodities, and technology from more advanced countries (Falvey et al. 2001; Weinhold and Rauch 1999).

A very attractive feature of trade shares is that the last several years' data are *readily available* for most countries from their balance of payments accounts. This might be the main reason for the high popularity of traditional measures of openness in the empirical literature. Brahmbhatt (1998) finds outcome-based indices most useful in judging trends in international market integration over time. If the interest not only lies in whether or not openness is increasing or decreasing but also whether it is high or low then a standard against which actual outcomes can be compared is required. Deviation measures emphasize the additional information.

Several attempts have been made to *increase the accuracy* of how traditional proxies of openness indicate the importance of international trade relationships for a country. This has been attempted by isolating the variation in shares of trade, which is attributable to a variety of determinants of interest, such as trade policy or non-policy variables (see, for example, Harrison 1996). *Measures of deviations* of observed trade volume or price from the predicted free-trade volume or price are an effort to enhance outcome measures, such as the conventional shares of trade. For example, models based on the law of one price, Heckscher-Ohlin models, gravity models of trade, and computable general equilibrium models generate predictions of a country's propensity to international or bilateral trade. Deviations of the observed trade volume or price from the potential outcome provide a measure of the restrictiveness of a country's trade regime.

Pritchett (1996) emphasizes a number of conceptual weaknesses of deviation-based indicators of trade openness, such as the lack of a well grounded theoretical model of trade intensity as well as the high sensitivity of the results to assumptions about the adopted theoretical model and the empirical specifications. Furthermore, deviation measures do not signal openness in a uniform way. Brahmbhatt (1998) comments on the intrinsic difficulty of the role of deviation indices for providing an appropriate standard against which actual outcomes can be judged. Deriving a benchmark of comparison often requires making additional assumptions about economic integration or behavior of economic agents. It is difficult to tell whether the deviation between actual and predicted outcome represents the degree of trade openness or if it is a sign that assumptions need to be questioned.

Wacziarg (2000) draws attention to some additional shortcomings of openness measures based on deviations. Determinants of potential trade may have been omitted. As a result, the predicted outcome may not adequately measure the realization that would exist under complete free trade. Furthermore, some gravity or endowment determinants of prospective trade may be strongly correlated with policy attitudes. In such a case, the deviation of actual from predicted trade may exclude some valid information about policy. Finally, if the observed outcome contains a white noise disturbance term then deviations from the prediction will also contain a white noise disturbance, which leads to an increased downward bias, which is in turn associated with a measurement error.

Knetter and Slaughter (2001) point out that deviation measures do not link outcomes back to barriers of trade. Without these linkages it is not possible to separate other factors from changed barriers that affect the quantity or price of trade. Economic growth might be such a factor. On the other hand, they emphasize that for many important issues a distinction between the causes of trade integration is not relevant. “For example, if changes in a country’s

relative product prices are raising domestic wage inequality, the outcome is the same for workers whether it is caused by reduced transaction costs or by growth abroad."

In addition, *administrative measures* describe the institutional features of a country's attitude towards trade. Wacziarg (2000) summarizes some disadvantages of the policy indices. They face endogeneity problems in their relationship with growth, and the availability of administrative indices tends to be limited. Furthermore, these indicators "may not directly reflect the degree of effective protection faced by domestic agents, but only the legal framework to which they are confronted." Knetter and Slaughter (2001) add that most policy measures are suggestive and give three limitations. Most tariff measures omit the cost of prohibitive barriers, that is, a situation where tariffs or transportation costs are so high that a country's imports are zero. Many concepts completely omit all non-tariff barriers. Non-tariff barriers have, in recent years, evolved into the primary barriers of trade between countries in many product categories. Even if data of non-tariff barriers are available, they could not likely be easily quantified as a cost of moving goods or services. Also Spilimbergo et al. (1999) point out the two latter shortcomings of direct indicators of trade policy.

Pritchett (1996) concludes that deviation indicators generally show a low association with a range of other measures of trade openness. Moreover, in 30 percent of comparisons, countries scored as open by one measure are scored as closed by another one. Beside this, implausible rankings of some countries reveal conceptual and empirical limitations of deviation indices (Dollar 1992). Leamer (1988) questions the usefulness of deviation measures. An adjustment of traditional concepts by administrative measures does not lead to satisfying results either. Pritchett (1996) shows that various policy indices are only weakly correlated among themselves. No single policy measure could adequately capture a country's outward orientation. Furthermore, Harrison (1996) examines the rank correlation between seven different measures of openness based on outcome, deviation, and policy concepts. The majority of rank correla-

tions are not statistically significant. The lack of a correlation between all the openness indices might indicate that the measures capture different aspects of trade openness.

Lastly, *outcome-based adjustments* of the established trade shares aim to improve the representation of 'openness' for cross-country comparisons. In general, the denominator of the trade shares and, thus, the gross domestic product (GDP) is corrected. For example, adjusted trade shares take the Balassa-Samuelson effect, a country's size, or its maturity into account. An amendment of such effects seems to advance the quality of empirical analysis based on trade openness (Brahmbhatt 1998). But the adjustment of traditional openness measures with such approaches might not be far-reaching enough because their construction disregards the fact that the common interpretation of the conventional shares of trade is misleading.

The traditional shares of trade openness at the export side attempt to indicate a country's surplus production. In addition, it is supposed that the dependency of a country's residents on imports is measured at the import side (Kotcherlakota and Sack-Rittenhouse 2000). The interpretation of these trade shares sounds correct but these indices do not indicate what they are supposed to. Traditional shares of trade are confusing because they do not take the international redistribution of income generated by trade into account.

Exports do not exclusively create income in the country which sells goods and services to foreign countries; they also engender income in the country's trading partners due to imported intermediate inputs to produce exports. The common interpretation of a country's degree of openness to trade based on the traditional trade shares at the export side overstate the potency of a country to build surplus production at home. Imported intermediate products which are assembled in exports are not part of the national income of the domestic economy. Goods and services sold to foreigners only create income for the residents when the domestic factors of production are involved in the process of production. Moreover, approaches which only adjust

the denominator are too short-handed to improve the quality of the export ratio. The numerator simply represents only one share of the denominator.

The widespread explanation of traditional trade shares at the import side is criticized in a similar way to the argument before. Residents of the home country are not dependent on all parts of imports as the index of openness, such as the intra-regional import ratio, suggests. They have to spend a lower portion of their income to purchase goods and services from abroad. Imports are partly produced with intermediate products delivered by other countries. These countries include the home country. Hence, international trading partners purchase intermediates from the domestic economy to assemble, for example, imports for the home country which, in turn, generates income for the domestic factors of production. Domestic residents do not have to spend as much of their income as was expected by the traditional proxy of openness.

Brahmbhatt (1998) points out that since "trade data is stated in gross terms, while GDP is stated in value added terms, this can lead to an inflation in" traditional measures of openness. The value of exports consists of the value of imported intermediates and the value of domestic factors of production. Value added denotes the income that domestic residents receive for their employment in the process of production. A *solution* could be either to state trade in value-added terms or to state national income in gross output terms. We could not find a concept in empirical literature which follows either of these ideas. A simple reason for the lack of value-added based adjustments of traditional trade shares might be that the availability of such data is limited (Brahmbhatt 1998). Knetter and Slaughter (2001) also raise this problem with data on imported intermediate inputs. They introduce the measure of production fragmentation which is the ratio of value added to total output within industries. The total output of an industry denotes the value of all intermediate and final products that an industry produces within a given time for other industries as well as for consumption and investment. A

decreasing value is interpreted as a raise in imported intermediate products. This index of openness excludes imports of final goods and services because it is constructed to exclusively emphasize the narrowing of production activities within countries.

In this contribution, two new measures of openness to bilateral trade are introduced which attempt to solve the problem stated by Brahmbhatt (1998). They adjust traditional shares of trade by expressing *trade in value-added terms* instead of gross terms. This value-added based approach is in clear contrast to the mainstream. Common corrections of the gross domestic product are very likely increasing the accuracy of cross-country comparisons but the fundamental difficulty of traditional openness indices is untouched. The numerator is still expressed in gross terms whereas the denominator is stated in value-added terms. We denote degrees of openness which are calculated by the traditional shares of trade as '*traditional openness*' whereas the term '*actual openness*' represents the results of the newly adjusted trade shares.

The remainder of this contribution proceeds as follows. Section 2 presents the new concept of actual openness which adjusts the well-established indices of openness towards intra-regional trade by the means of value-added based openness proxies. Subsequently, in Section 3 the empirical comparison of the degrees of openness based on traditional and actual openness is highlighted. Section 4 gives some conclusions of the study.

2. Actual openness of intra-regional trade

2.1 The multi-regional input-output table

The innovative measures of trade openness in this article adjust the traditional shares of trade by emphasizing the value added that intra-regional trade generates. Such a correction of the trade values that are stated in gross terms requires an *analysis of income effects* due to trade. The analysis must take the process of production in an economy into account since the interdependences between industries determine the employment of inputs for the production of

output in the industries. Consequently, the input-output analysis is an appropriate instrument for the development of new trade shares.

We will carry out a *multi-regional input-output analysis* in an open static Leontief system which describes the economic system of the world economy not only in terms of interdependent industries within a region but also in terms of the interrelated regions' home country, aggregated integration area, and aggregated foreign country. The 'integration area' region stands for all regional trading partners of the home country, such as the member states of the European Union (EU), and the 'rest of the world' region includes those economies outside the region. A national input-output analysis of a country which ignores the process of production in the foreign countries would restrict the construction of new proxies of openness on the export side of the economy. Consequently, it is necessary to include national input-output analyses of the foreign trading partners to expand the measurement of actual openness on the import side of the country of interest because only this allows the international redistribution of income created by trade to be calculated.

The decision to choose the *open static Leontief system* as the theoretical foundation for the input-output analysis and not, for example, the Straffa system was based on the aim of this study to calculate new degrees of trade openness (Leontief 1966; Straffa 1960). Preference was given to the contribution of Leontief to the theory of production, which is inspired by essentially empirical concerns whereas the Straffa system was developed for basically theoretical purposes (Pasinetti 1977: 32, 71). In addition, the applied Global Trade Analysis Project (GTAP) data base offers data which fit the Leontief system (GTAP 2003; see McDougall and Dimaranan 2002; Gehlhar et al. 1997).

The data base does not include data to construct more comprehensive non-linear or dynamic input-output models. A linear approximation of the production processes within a country is appropriate if exports induce small variations in the production of the economy. In such a

case, the output effects of increasing or decreasing returns to scale are limited. In other cases, the non-linearity of the production relationships could lead to deceptive conclusions. For such a short period of time, the assumption of a static economy is suitable even for noticeably dynamic economic systems because the changes in technical knowledge which affect the technical coefficients can normally be neglected (Pasinetti 1977: 69).

The *multi-regional input-output table* in this study systematically defines all transactions within a certain country and the foreign countries, which are separated into two groups, as well as between the regions. Its construction mainly follows the scheme proposed by Isard (1951). This method is superior to others, such as Leontief (1966), because it incorporates less simplifying assumptions of interregional interconnections. Consequently, this allows a very detailed study of the economic interdependences but it also demands a lot of data which the GTAP (2003) data base is able to supply. The multi-regional input-output table consists of the national input-output table of a country under investigation and the national input-output tables of its trading partners which are then aggregated to build a national input-output table for the 'integration area' region and for the 'rest of the world' region.

This aggregation of national input-output tables deviates from the idea developed by Isard (1951) of including each country of interest in the multi-regional input-output table. With the construction of a single national input-output table it is possible to significantly reduce the complexity of the creation of value-added based measures of trade openness. On the other hand, this approach could lead to an aggregation error due to a simplified representation of interdependences between regions (see, for example, Mythili 1995; Kossov 1970; Theil 1957). The quality of the approximate results could be evaluated by comparing the total output predictions with a multi-national input-output table which consists of all relevant national input-output tables. Since imports from a certain country are only a fraction of total imports,

they generally induce little changes in every single trading partner. Therefore, this approximation of interconnections between the foreign countries should be legitimate.

Figure 1 illustrates the multi-regional input-output table.

Figure 1: Multi-regional input-output table with three regions

			Region *l*																			
			1				2				3				1			2			3			
			Industry *j*												Demand *e*									
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2	3	
Region *k*	1	1	X_{ij11}				X_{ij12}				X_{ij13}				Y_{ie11}			Y_{ie12}			Y_{ie13}			X_{i1}
		2																						
		3																						
	2	1	X_{ij21}				X_{ij22}				X_{ij23}				Y_{ie21}			Y_{ie22}			Y_{ie23}			X_{i2}
		2																						
		3																						
	3	1	X_{ij31}				X_{ij32}				X_{ij33}				Y_{ie31}			Y_{ie32}			Y_{ie33}			X_{i3}
		2																						
		3																						
Commodity *i*		4																						
	Factor *g*	1	W_{gj1}				W_{gj2}				W_{gj3}													
		2																						
		3																						
		4																						
		5																						
			X_{j1}				X_{j2}				X_{j3}													

The input-output table is constructed in current dollar terms which refer to a period of one year. The symbol X_{ijkk} represents an element of the *intermediate inputs matrix* of region *k*. It denotes the value of commodity *i* which is delivered to industry *j* within region *k*. Region *k* represents either the home country (1), the integration area (2), or the rest of the world (3). Commodity *i* symbolizes food (1), other primary products (2), manufactures (3), or services (4). Correspondingly, industry *j* stands for food industry (1), other primary production (2), manufacturing (3), or services (4). It is assumed that each industry produces only one type of product and each product within the industry is the same. For example, manufacturing pro-

duces only manufactured products. The distribution and sale of the manufactures is fixed. Furthermore, region *k* exports the value of commodity *i* to industry *j* of region *l*, denoted by the symbol X_{ijkl}. Region *l* indicates either the home country (1), the integration area (2), or the rest of the world (3). Since these exports of one region are imported intermediate inputs for the other region, X_{ijkl} is an ingredient of the *primary inputs matrix* of region *l*.

The *demand matrix* of region *k* includes the value of the *i*th commodity which is produced in region *k* and demanded by the final demand component *e* of region *k*, indicated by the symbol Y_{iekk}. This component *e* of final demand is either in the home country (1), in the integration area (2), or in the rest of the world (3). Thus, Y_{ikkk} represents the value of purchases of consumers and the government as well as the value of investment activities of firms of commodity *i* in the region *k* whereas the symbol Y_{ilkk} describes the export value of commodity *i* of region *k* which the residents in region *l* demand. This definition of final demand can be expressed as

$$\sum_{e=1}^{3} Y_{iekk} = Y_{ikkk} + \sum_{l \neq k} Y_{ilkk}, \quad i = 1,2,3,4, \quad k = 1,2,3. \tag{1}$$

The exports of commodity *i* of region *k* include deliveries to the production processes as well as to final demand in region *l*. Since it is assumed that the value of an exported commodity *i* equals its import value, the export value of commodity *i* of region *k* is in symbols:

$$Y_{ilkk} = \sum_{j=1}^{4} X_{ijkl} + \sum_{e=1}^{3} Y_{iekl}, \quad i = 1,2,3,4, \quad k = 1,2,3, \quad l \neq k. \tag{2}$$

As an element of the *demand matrix*, the symbol Y_{iekl} denotes the value of commodity *i* which the final demand component *e* of region *l* imports from region *k*. With this approximation of trade relationships between the regions, (1) can be rewritten as

$$\sum_{e=1}^{3} Y_{iekk} = Y_{ikkk} + \sum_{j=1}^{4} \sum_{l \neq k} X_{ijkl} + \sum_{e=1}^{3} \sum_{l \neq k} Y_{iekl}, \quad i = 1,2,3,4, \quad k = 1,2,3. \tag{3}$$

In contrast to the common definition of final demand, this version separates explicitly the exports of intermediate inputs from exported final products. Consequently, the value of the exported commodity *i* is included two times in the multi-regional input-output table. On the one hand, as part of the final demand of region *k* (Y_{ilkk}) and, on the other hand, as imports in region *l* (X_{ijkl} and Y_{iekl}). This treatment of exports enhances the approach of Isard (1951). Our multi-regional input-output table describes the interregional interdependences more accurately than the alternative scheme because imports from the other regions for the final demand are included in the final sector and not simplified as intermediate inputs for the industries which then deliver the imports to the final sector.

X_{ik} symbolizes the value of *total output* of commodity *i* in region *k*. It is determined by the requirement of the intermediate input *i* by all industries *j* to produce output (X_{ijkk}) and the demand of the final product *i* by the components *e* of final demand (Y_{iekk}), which is represented in symbols as

$$X_{ik} = \sum_{j=1}^{4} X_{ijkk} + \sum_{e=1}^{3} Y_{iekk}, \quad i = 1,2,3,4, \quad k = 1,2,3. \tag{4}$$

As noted before, the multi-regional input-output table in this study treats trade between the regions in such a way that the structure of exports are reflected in more detail as the scheme of Isard (1951). If we take (3) into account then the value of total output of commodity *i* in region *k* which is expressed in (4) becomes

$$X_{ik} = \sum_{j=1}^{4} X_{ijkk} + \sum_{j=1}^{4} \sum_{l \neq k} X_{ijkl} + Y_{ikkk} + \sum_{e=1}^{3} \sum_{l \neq k} Y_{iekl}, \quad i = 1,2,3,4, \quad k = 1,2,3. \tag{5}$$

The equation shows the flow of commodities *i* to the intermediate sector of region *k* and region *l* (X_{ijkk} and X_{ijkl}), to final demand within region *k* (Y_{ikkk}), and to the final sector of region *l* (Y_{iekl}).

Furthermore, an industry requires several inputs to carry on its activities. The sum of all inputs of the industry is called total output – the same as the sum of outputs of the industry. In-

dustries purchase intermediate commodities from other industries (X_{ijkk}) and employ imported intermediate inputs (X_{ijkl}) as well as domestic factors of production (W_{gjk}). The symbol W_{gjk} denotes the compensation of production factor *g* in industry *j* in region *k* and is the missing element of the *primary inputs matrix* of region *k*. Factor of production *g* is unskilled labor (1), skilled labor (2), capital (3), land (4), or natural resources (5). Thus, the value of *total output* of industry *j* in region *k*, denoted by X_{jk}, is defined in symbols as

$$X_{jk} = \sum_{i=1}^{4} X_{ijkk} + \sum_{i=1}^{4} \sum_{l \neq k} X_{ijlk} + \sum_{g=1}^{5} W_{gjk}, \quad j = 1,2,3,4, \quad k = 1,2,3. \tag{6}$$

The value of total output in (4) (and (5)) equals the outcome in (6) because the value of all outputs of an industry is exactly the same value as all of its inputs:

$$X_{ik} = X_{jk}, \quad i = 1,2,3,4, \quad j = i, \quad k = 1,2,3. \tag{7}$$

Finally, the multi-regional input-output table includes also the *gross domestic product* in region *k*, denoted by the symbol Y_k. The gross domestic product is defined as the sum of the value added in the industries which industries generate in the domestic economy due to their compensation of production factors for their employment in the production process of outputs. Because domestic residents spend a part of this income on domestic final goods and services and the industries export part of their outputs to foreign residents, gross domestic product can be expressed in symbols as

$$Y_k = \sum_{g=1}^{5} \sum_{j=1}^{4} W_{gjk} = \sum_{i=1}^{4} \sum_{e=1}^{3} Y_{iekk} - \sum_{i=1}^{4} \sum_{j=1}^{4} \sum_{l \neq k} X_{ijlk}, \quad k = 1,2,3. \tag{8}$$

The value of imported intermediate inputs is subtracted from the value of final demand because domestically produced final goods and services include imported intermediate inputs which do not generate value added in the home economy.

2.2 Input-output analysis of bilateral trade relationships

Now that the intra- and inter-regional economic interconnections have been described in the multi-regional input-output table, they can be evaluated by the following input-output analysis. The first step of the analysis of income effects due to exports is the forecast of the *change of total output* in the domestic economy. Any output of an industry including goods and services sold to foreign residents requires intermediate inputs from the industry and supplying industries for the production of the output. All the involved industries also require their own intermediate commodities from their suppliers and so forth. Consequently, the value of total output includes the export value and the value of all intermediate inputs to produce the exported output.

The association between the value of exports that are interpreted as a change in the value of final demand and the response of the value of total output which is determined by the interdependences of the industries is described next. We begin with the *inter-industry coefficient* (also technical coefficient of the production processes or merely production coefficient). The inter-industry coefficient a_{ijk} represents the fraction of total expenditures of industry j which is spent to purchase the commodity i in region k as

$$a_{ijk} = \frac{X_{ijkk}}{X_{jk}}, \quad i, j = 1,2,3,4, \quad k = 1,2,3. \tag{9}$$

The ratio expresses the quantity of the ith commodity which is on average required in the jth industry for the production of one unit of the jth commodity in region k. Because commodities do not have negative values, it follows that

$$a_{ijk} \geq 0, \quad i, j = 1,2,3,4, \quad k = 1,2,3. \tag{10}$$

Equation (9) shows the fundamental assumption of the Leontief system; the inter-industry coefficients are constant, this is, constant returns to scale are assumed. Price effects, economies of scale, or changes in technical knowledge that influence the requirement for inputs to

produce output in an industry are not considered. There is no substitution between inputs. When taking into account that the technology of the production process is fixed, the amount of a commodity *i* purchased by an industry *j* in region *k* is determined only on the level of its output of commodity *j*:

$$X_{ijkk} = a_{ijk} X_{jk}, \quad i, j = 1,2,3,4, \quad k = 1,2,3. \tag{11}$$

Consequently, (4) which defines the value of the total output of commodity *i* in region *k* can be rewritten as

$$X_{ik} = \sum_{j=1}^{4} a_{ijk} X_{jk} + \sum_{e=1}^{3} Y_{iekk}, \quad i = 1,2,3,4, \quad k = 1,2,3. \tag{12}$$

Since the value of all outputs of an industry (X_{ik}) equals the value of all of its inputs (X_{jk} with $i = j$), X_{jk} can be replaced by X_{ik}, as stated in (7), and hence it follows that

$$X_{ik} = \sum_{j=1}^{4} a_{ijk} X_{ik} + \sum_{e=1}^{3} Y_{iekk}, \quad i = 1,2,3,4, \quad k = 1,2,3. \tag{13}$$

To find out what effect a change in the value of final demand, such as the value of exported goods and services within a year, has on the value of the total output in all industries of a region, (13) must be rearranged. First, we rewrite the equation concisely. The column vector of the four values of the commodities *i* which make up the final demand in region *k* is represented by y_k as

$$y_k = \left(\sum_{e=1}^{3} Y_{1ekk}, \sum_{e=1}^{3} Y_{2ekk}, \sum_{e=1}^{3} Y_{3ekk}, \sum_{e=1}^{3} Y_{4ekk} \right)^{T}, \quad k = 1,2,3. \tag{14}$$

x_k symbolizes the column vector of the four total output values of each commodity *i* which have to be produced in region *k* (X_{ik}). It can be stated as

$$x_k = (X_{1k}, X_{2k}, X_{3k}, X_{4k})^{T}, \quad k = 1,2,3. \tag{15}$$

The technique of a region *k*'s economic system is represented by the *direct requirements table* of the production processes A_k. It is the non-negative square matrix of inter-industry coefficients of order four which relates the inputs and outputs of commodities:

$$A_k = (a_{ijk}) = \begin{pmatrix} a_{11k} & a_{12k} & a_{13k} & a_{14k} \\ a_{21k} & a_{22k} & a_{23k} & a_{24k} \\ a_{31k} & a_{32k} & a_{33k} & a_{34k} \\ a_{41k} & a_{42k} & a_{43k} & a_{44k} \end{pmatrix}, \quad k = 1,2,3. \tag{16}$$

Based on these definitions, (13) can be rewritten as

$$x_k = A_k x_k + y_k, \quad k = 1,2,3. \tag{17}$$

The system of linear equations states that the value of the total output of region *k* equals the combined value of internal and final demand. A rearrangement of x_k to the left side leads to

$$x_k - A_k x_k = y_k, \quad k = 1,2,3. \tag{18}$$

By taking the identity matrix of order four (B):

$$B = (b_{rs}) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \quad b_{rs} = \begin{cases} 1 \text{ for } r = s \\ 0 \text{ for } r \neq s \end{cases} \tag{19}$$

into account it follows that

$$Bx_k - A_k x_k = y_k, \quad k = 1,2,3 \tag{20}$$

which leads to

$$(B - A_k) x_k = y_k, \quad k = 1,2,3. \tag{21}$$

Symbol b_{rs} represents an element of the identity matrix with the row index *r* and the column index *s*. The result of the final rearrangement of (17) is the solution of the static open Leontief system which is in symbols:

$$x_k = (B - A_k)^{-1} y_k, \quad k = 1,2,3. \tag{22}$$

For region *k,* it states, in value terms, the association between a given change in the structure of final demand and the response of the total output of the various industries necessary to produce not only the demanded commodities but also the required intermediate commodities in the production processes of the final goods and services. It is assumed that the supply of re-

sources is infinite and perfectly elastic as well as that all resources are efficiently employed (OECD 1992). In addition, the relation between the final sector and the intermediate sector clearly shows that the values of final demand are assumed to be exogenous variables of the input-output model whereas the values of total output are considered to be endogenous variables. But components of final demand, such as households, are involved in the process of production. The level of employment affects the demand of households. Since households are a part of the economic system, they would become endogenous variables of the input-output model. This aspect of the model's design is of minor relevance for the analysis of income effects due to exports because the spending of the induced national income by the households is not investigated.

The inverse matrix of order four in (22) is the *total requirements table* of the production processes $(B\text{-}A_k)^{-1}$, which is defined in symbols as

$$\left(B - A_k\right)^{-1} = \left(f_{ijk}\right) = \begin{pmatrix} f_{11k} & f_{12k} & f_{13k} & f_{14k} \\ f_{21k} & f_{22k} & f_{23k} & f_{24k} \\ f_{31k} & f_{32k} & f_{33k} & f_{34k} \\ f_{41k} & f_{42k} & f_{43k} & f_{44k} \end{pmatrix}, \quad k = 1,2,3. \tag{23}$$

Its elements are the *interdependence coefficients*, denoted by f_{ijk}. The interdependence (interindustry) coefficient f_{ijk} (a_{ijk}) represents the quantity of the *i*th commodity which is required in the economic system as a whole (on average in the *j*th industry) for the production of one unit of the *j*th commodity as a final commodity (as output for intermediate and final use) in region *k*. Thus, the total requirements table $(B\text{-}A_k)^{-1}$ does not only measure the direct effects, like the direct requirements table A_k, but also the indirect effects of any changes in the various industries.

In the second and third step, the value of domestic factors of production and the value of the imported intermediate inputs that are employed in the production processes of all involved industries to produce the exports in region *k* are forecasted. The analysis reveals, on the one

hand, how much income exports engender in the domestic economy (*domestic value added* induced by exports) and, on the other hand, how much income is transferred abroad due to the imported intermediate inputs that are processed in the exports (*foreign value added* induced by exports).

The *direct requirements table of domestic production factors* for region k, denoted by D_k, adds to the part of the direct requirements table already presented – the direct requirements table of the production processes A_k. Beside the description of the interdependences between the industries, this additional component of the table shows the structure of the production factors employed in the industries due to the production processes in the economy which, in symbols, is

$$D_k = \left(d_{gjk}\right) = \begin{pmatrix} d_{11k} & d_{12k} & d_{13k} & d_{14k} \\ d_{21k} & d_{22k} & d_{23k} & d_{24k} \\ d_{31k} & d_{32k} & d_{33k} & d_{34k} \\ d_{41k} & d_{42k} & d_{43k} & d_{44k} \\ d_{51k} & d_{52k} & d_{53k} & d_{54k} \end{pmatrix}, \quad k = 1,2,3. \tag{24}$$

This matrix consists of coefficients known as *technical coefficients of the domestic production factors* (d_{gjk}). The coefficient expresses the share of total expenditure of an industry j which is spent to compensate the factor of production g in region k:

$$d_{gjk} = \frac{W_{gjk}}{X_{jk}}, \quad g = 1,2,\ldots,5, \quad j = 1,2,3,4, \quad k = 1,2,3. \tag{25}$$

It is assumed that the coefficients are constant, the primary inputs are not substitutable, the production factors are not constrained, and the factors of production are efficiently employed. From the economic meaning of the coefficient it follows that

$$d_{gjk} \geq 0, \quad g = 1,2,\ldots,5, \quad j = 1,2,3,4, \quad k = 1,2,3. \tag{26}$$

Next, the change in the exogenous vector of final demand values of region k is determined by the vector of export values of the various commodities i sold from region k to region l. It can be written in symbols as

$$\mathrm{y}_k = \left(\mathrm{Y}_{1lkk}, \mathrm{Y}_{2lkk}, \mathrm{Y}_{3lkk}, \mathrm{Y}_{4lkk}\right)^{\mathrm{T}}, \quad k = 1,2,3, \quad l \neq k.^{1} \tag{27}$$

The commodities which are represented by the vector of export values y_k require not only the production of these commodities sold by foreign residents, but also intermediate commodities in the industries at the different levels of the stages of production within the economy, that is, the change of total output of the various industries expressed in value terms. This association is stated in (22). In addition to the intermediate commodities, domestic factors of production (and imported intermediate commodities) are employed in the production process of the exports. The compensation of the different factors of production *g* in region *k* is defined by the column vector of income of domestic production factors q_k as

$$\mathrm{q}_k = \left(\mathrm{Q}_{1k}, \mathrm{Q}_{2k}, \mathrm{Q}_{3k}, \mathrm{Q}_{4k}, \mathrm{Q}_{5k}\right)^{\mathrm{T}}, \quad k = 1,2,3. \tag{28}$$

Using the direct requirements table of domestic production factors D_k, the income of the production factors q_k due to the direct and indirect employment in the production of exports in region *k* is

$$\mathrm{q}_k = \mathrm{D}_k \mathrm{x}_k, \quad k = 1,2,3. \tag{29}$$

Hence it follows that the *export-induced domestic value added* of region *k* represents the total income of the different production factors *g* in region *k* generated by exports.

Lastly, the *direct requirements table of imported intermediate products* for region *k* (C_{lk}) completes the direct requirements table and is defined in symbols as

$$\mathrm{C}_{lk} = \left(\mathrm{c}_{ijlk}\right) = \begin{pmatrix} \mathrm{c}_{11lk} & \mathrm{c}_{12lk} & \mathrm{c}_{13lk} & \mathrm{c}_{14lk} \\ \mathrm{c}_{21lk} & \mathrm{c}_{22lk} & \mathrm{c}_{23lk} & \mathrm{c}_{24lk} \\ \mathrm{c}_{31lk} & \mathrm{c}_{32lk} & \mathrm{c}_{33lk} & \mathrm{c}_{34lk} \\ \mathrm{c}_{41lk} & \mathrm{c}_{42lk} & \mathrm{c}_{43lk} & \mathrm{c}_{44lk} \end{pmatrix}, \quad k = 1,2,3, \quad l \neq k. \tag{30}$$

[1] Depending on the focus of the analysis, either economies in one of the regions *l* or all foreign countries are taken into account to define the export vector.

Its elements – the *technical coefficients of the imported intermediate inputs*, denoted by c_{ijlk}, – express the quantity of the *i*th commodity imported from region *l* which is essential in the *j*th industry for the production of one unit of the *j*th commodity in region *k*. The ratio can be written as

$$c_{ijlk} = \frac{X_{ijlk}}{X_{jk}}, \quad i, j = 1,2,3,4, \quad k = 1,2,3, \quad l \neq k. \tag{31}$$

The assumptions about the employment of the imported intermediate commodities in the production process of output are identical to those for the production factors presented earlier. In addition, only positive values of the coefficient are economically plausible:

$$c_{ijlk} \geq 0, \quad i, j = 1,2,3,4, \quad k = 1,2,3, \quad l \neq k. \tag{32}$$

We will now introduce the last vector of the input-output analysis of income effects due to bilateral trade which represents the value of imported intermediate commodities *i* in region *k* bought from region *l*. The column vector p_{lk} is expressed in symbols as

$$p_{lk} = \left(P_{1lk}, P_{2lk}, P_{3lk}, P_{4lk}\right)^{T}, \quad k = 1,2,3, \quad l \neq k. \tag{33}$$

The demand for exports induces the production of these final commodities as well as inducing the intermediate commodities to produce goods and services that foreign residents desire. This change in total output requires, beside domestic inputs, intermediate commodities from abroad as determined by the structure of production within the industries:

$$p_{lk} = C_{lk} x_k, \quad k = 1,2,3, \quad l \neq k. \tag{34}$$

Finally, the *export-induced foreign value added* of region *k* indicates the value of all imported intermediate commodities *i* of region *k* which are included in the region's exports.

2.3 Value-added based measures of openness towards an integration area

Trade with the member states of an integration area generates value added in a country as a result of its exports (q_1). The exports within the period of one year (y_1) require not only the

production of the export products, but also intermediate commodities in the production processes of the exporting industries and their supplying industries. This production of final commodities and additional intermediate commodities is stated by the change of total output (x_1), which is expressed in value terms. In addition to the intermediate commodities, the directly and indirectly involved industries employ primary inputs, such as domestic factors of production. The compensation of the production factors equals the change in the industries' value added (q_1). If we express this part of national income as a share of the whole national income in the domestic economy (Y_1) then we obtain the *intra-regional export-induced domestic value-added ratio* openness indicator, abbreviated by IEDR. It can be written in symbols as

$$\begin{aligned} &y_1 = \left(Y_{1211}, Y_{2211}, Y_{3211}, Y_{4211}\right)^T, \quad x_1 = \left(B - A_1\right)^{-1} y_1, \quad q_1 = D_1 x_1, \\ &\text{IEDR} = \frac{q_1}{Y_1} 100. \end{aligned} \tag{35}$$

Since the numerator represents a part of the denominator, the range of the value-added based index of openness is between zero and 100 percent. The adjusted trade ratio can be interpreted in such a way that a higher degree of openness means that a country depends more on foreign countries in the integration area to create income in the domestic economy.

A further attempt to indicate openness towards an integration area with more accuracy than the traditional shares of trade is the *intra-regional import-induced intra-regional value-added ratio* (IIIR) indicator. This proxy of openness calculates the degree of openness on a country's import side for the period of one year with the focus on income that imports generate in the integration area. The IIIR puts the export-induced regional value added of the integration area (q_2 and p_{23}) in relation to the national income in the domestic economy (Y_1) as

$$\begin{aligned} &y_2 = \left(Y_{1122}, Y_{2122}, Y_{3122}, Y_{4122}\right)^T, \quad x_2 = \left(B - A_2\right)^{-1} y_2, \quad q_2 = D_2 x_2, \\ &y_3 = \left(Y_{1133}, Y_{2133}, Y_{3133}, Y_{4133}\right)^T, \quad x_3 = \left(B - A_3\right)^{-1} y_3, \quad p_{23} = C_{23} x_3, \\ &\text{IIIR} = \frac{q_2}{Y_1} 100 + \frac{p_{23}}{Y_1} 100. \end{aligned} \tag{36}$$

The '*export-induced regional value added*' consists of the income created in the member countries of the integration area via direct and indirect imports of the home country from the integration area. q_2 represents the export-induced domestic value added of the integration area due to exports to the home country and p_{23} symbolizes the export-induced foreign value added of the rest of the world in the integration area. Trading partners outside the integration area require intermediate commodities from countries in the integration area (and the home country) to produce exports for the home country. This generates value added in the integration area that is not due to the imports of the home country from the integration area.

It is possible that the non-negative level of openness calculated by the IIIR measure surpasses 100 percent. Such a situation indicates that domestic residents spend more of their income on imported intermediate commodities embodied in exports than they are compensated for by the industries. The domestic economy must be able to close its financial deficiency by means of exports or international borrowing. The higher the degree of openness is, the more important are foreign trading partners within the integration area for the spending of domestic residents' income.

3. Comparison of degrees of openness based on traditional and actual openness

3.1 The data set

As a starting point of the empirical analysis, we calculate and present the empirical realizations of the degree of openness of 21 countries which are members of the EU, NAFTA, and MERCOSUR for the year 1997 according to the traditional and actual openness concept. Paraguay is not included in this cross-sectional sample since data were not available. The Global Trade Analysis Project (*GTAP*) Data Base Version 5.4 (GTAP 2003) is the source of data for the calculation of the trade shares. This data base represents the economic conditions for 78 regions and the economic linkages between these regions for the year 1997 in US dol-

lar terms. In addition, these interdependences are described for 57 commodities and the industries employ five different factors of production; unskilled labor, skilled labor, capital, land, and natural resources (McDougall and Dimaranan 2002). Subsequently, the 57 commodities are aggregated to form four commodities; food, other primary products, manufactures, and services. The aggregation level of the production factors remains unchanged.

Table 1 presents the *outcomes* of the measures of openness of both the value-added based and traditional openness concept on the export and import side of the countries under investigation.

Table 1: Actual and traditional openness to bilateral trade, 1997 (percent of GDP)

Percent of GDP, 1997	Export side		Import side	
	IEDR	IER	IIIR	IIR
MERCOSUR				
Argentina	2.4	2.7	2.0	2.2
Brazil	0.8	0.9	1.1	1.2
Paraguay	....	....	....	....
Uruguay	5.7	7.1	8.3	9.0
NAFTA				
Canada	19.2	27.1	20.0	22.5
Mexico	17.7	23.2	16.3	18.2
United States	2.2	2.6	2.4	3.3
EU				
Austria	14.8	21.1	23.4	26.8
Belgium	24.8	48.4	42.3	48.6
Denmark	16.1	21.7	18.0	20.7
Finland	15.0	20.7	16.7	18.9
France	11.8	14.5	12.1	14.3
Germany	11.3	14.1	11.4	13.6
Greece	6.7	7.8	14.4	16.3
Ireland	29.3	49.8	37.2	41.9
Italy	9.9	12.9	11.3	13.0
Luxembourg	25.9	50.6	47.3	54.1
Netherlands	25.7	42.1	27.4	31.0
Portugal	16.1	21.7	26.1	30.3
Spain	12.4	16.4	15.1	17.5
Sweden	15.7	22.1	19.5	22.3
United Kingdom	10.5	13.2	12.3	14.2

Source: Own calculations based on GTAP (2003).

A degree of openness of zero percent of the gross domestic product indicates a closed economy which finds itself in a status of complete autarky. The higher the empirical value is, the

more significant are the other member countries of an integration area, with respect to their trade relationships for the country of interest. Table 1 reveals that all empirical realizations of the degree of openness indicate a lower importance of the intra-regional trading partners of the countries when they are calculated by value-added based measures of trade openness instead of indicators of the established openness concept. Both methods describe the same economic situation a country faces but the new approach clearly reveals that exports create less income in the producer country than suggested by the standard trade shares. Export sectors and their supplying sectors demand imported intermediate commodities to produce exports that increase the wealth abroad rather than in the domestic economy.

For example, the trade activities of Argentina with its neighbors Brazil, Paraguay, and Uruguay are summarized by the country's degree of openness towards intra-regional trade. Table 1 demonstrates that the results of the alternative measures of openness to intra-regional trade range between 2.0 and 2.7 percent of the gross domestic product in the year 1997. For Argentina, both openness concepts reveal a very low level of regional trade openness. For instance, the country exports 2.7 percent of all final goods and services to MERCOSUR (IER). According to the IEDR measure, these exports lead to domestic income which amounts to 2.4 percent of the total earnings in Argentina. Within the same year, the expense for imports from the region represents a share of 2.2 percent of the national income (IIR). Only 2.0 percent of the income that the domestic production factors receive is transferred to the other members of MERCOSUR since imports include exported intermediates which create income in Argentina (IIIR).

3.2 Methodology

Several methods are applied to analyze whether indicating openness with the value-added based openness indices as opposed to traditional indices leads to *systematic effects* on the de-

gree of openness towards bilateral trade. The comparative analysis of the measures of openness based on the traditional and actual openness concept begins with the presentation of the countries' *rank order of openness* due to the alternative openness methods. This will disclose whether the value-added based openness indices display a similar rank order as when the traditional indicators are used. This would indicate that the innovative measures describe the same aspects of bilateral trade as the established proxies of openness. Since the main drawback of most approaches that try to adjust the traditional trade shares is their very poor correlation with the established indices, a superiority of the new concept of actual openness over many alternative methods would be indicated.

Subsequently, the value-added based openness proxies are characterized by a *visual analysis* to give an impression of the differences between the two alternative openness concepts. This includes the discussion of the degrees of actual and traditional openness. The visual analysis is complemented by a *frequency distribution analysis* that highlights key characteristics of the outcomes of the traditional and actual openness indices by means of standard statistical measures. Next, a *correlation analysis* accentuates the countries' rank order of openness. The elasticity of the degree of actual openness due to a change in the level of traditional openness is described with a *regression analysis* based on the ordinary least squares (OLS) method.

3.3 Outcomes and interpretation

The comparison of the value-added based indices of openness towards intra-regional trade with the traditional measures of openness begins with a presentation of the relative positions of the 21 member states of the three integration areas under investigation according to their degrees of openness towards intra-regional trade. Table 2 records the *rank order* of the study's four indicators in Table 1 for the year 1997. These rank orders begin with one for the

country with the lowest degree of openness, continue with two, three, …, and end with the total number of countries for the most integrated economy.

Table 2: Rank order of actual and traditional openness, 1997

Rank order, 1997	IEDR	IER	Rank order, 1997	IIIR	IIR
Export side			**Import side**		
Brazil	1	1	Brazil	1	1
United States	2	2	Argentina	2	2
Argentina	3	3	United States	3	3
Uruguay	4	4	Uruguay	4	4
Greece	5	5	Italy	5	5
Italy	6	6	Germany	6	6
United Kingdom	7	7	United Kingdom	8	7
Germany	8	8	France	7	8
France	9	9	Greece	9	9
Spain	10	10	Spain	10	10
Finland	12	11	Mexico	11	11
Austria	11	12	Finland	12	12
Denmark	15	13	Denmark	13	13
Portugal	14	14	Sweden	14	14
Sweden	13	15	Canada	15	15
Mexico	16	16	Austria	16	16
Canada	17	17	Portugal	17	17
Netherlands	19	18	Netherlands	18	18
Belgium	18	19	Ireland	19	19
Ireland	21	20	Belgium	20	20
Luxembourg	20	21	Luxembourg	21	21
Paraguay	....	....	Paraguay	....	....

Source: Own calculations based on GTAP (2003).

In ten of 42 cases (23.8 percent) countries change their positions in response to a shift of the applied measure for calculating the degree of openness towards intra-regional trade. Except for Denmark and Sweden where it is for two ranks, positions of the other eight economies vary for one rank. With respect to the rank order for the export (import) side, the actual openness concept leads to relatively similar (nearly identical) outcomes as with the traditional openness approach.

There is almost no variation in the ranking of the import side because the intra-regional import ratio (IIR) index almost correctly indicates the amount of income that domestic residents have to spend to purchase imports. The value-added based measure of openness (IIIR) improves its traditional counterparts by taking the redistribution of income generated by exports

into account but the value of exported intermediates which are assembled in imports is usually so small that it can be neglected.

The positions of some countries in the ranking are altered on the export side, but only one or two positions. This is the case because the traditional intra-regional export ratio (IER) increasingly overestimates the effect of trade on the domestic economy the more commodities a country exports in relation to all produced commodities. In more open economies, the focus of firms to re-export imports determines a larger fraction of imports than in less open countries. Firms which redistribute final commodities or process the finishing of imported intermediate commodities employ less domestic factors of production and thus contribute less to national income than other firms which produce the exports mainly with national intermediate commodities in all processing stages.

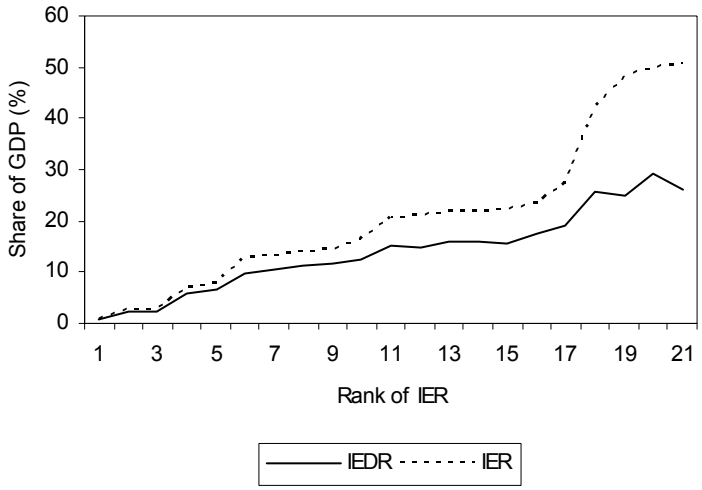
The measure of actual openness (IEDR) is able to model the fact that open countries have more re-exporting firms than closed countries, since this kind of production structure is less able to create income in the domestic economy. This result distinctly indicates that the measures of actual openness explain the same aspects of openness to bilateral trade as the indices of traditional openness do but with more accuracy, which are considerable improvements over many alternative concepts of openness measurement (see Harrison 1996).

Coming back to our previous example of Argentina, Table 2 indicates that the country is a relatively closed economy with rank three at the export side (IEDR and IER) and the second position at the import side (IIIR and IIR).

In the following, we search for *systematic disparities* between the empirical outcomes when different openness concepts are applied. As a starting point, we *visualize* the empirical results gained in the preceding overview. Figure 2 gives a brief visual impression of the empirical realizations of the degrees of openness from Table 1, dependent on the method used. The horizontal axis arranges the economies of the sample in an increasing order by their position

within the rank order of the IER measure. The vertical axis displays the empirical outcomes of the traditional and actual openness concept (IEDR and IER), respectively.

Figure 2: Actual and traditional openness on the export side, 1997 (percent of GDP)



Source: Own calculations based on GTAP (2003).

Figure 2 illustrates for *intra-regional export*, first, that actual openness (IEDR) is in all cases lower than traditional openness (IER). Consequently, the actual openness concept, as a rule, leads to lower measured degrees of openness as compared to the often applied and still popular traditional approach. Let us now once again draw attention to the fact that the IEDR indicator introduced in this paper cannot exceed 100 percent. Following this concept, it is simply not possible to use all of an economy's factors of production to exclusively manufacture export products since production factors earn income for the production of tradeables and non-tradeables.

However, in the case of the corresponding IER measure it cannot be excluded that the index indicates a degree of openness that is larger than 100 percent. For example, a country can export more goods and services than it produces for final demand when it serves as an international hub for the exchange of goods between other economies. Secondly, Figure 2 clearly reveals the tendency of the IEDR measure to increase with the IER. This means that the more products the industries of an economy sell to their regional trading partners, the more domes-

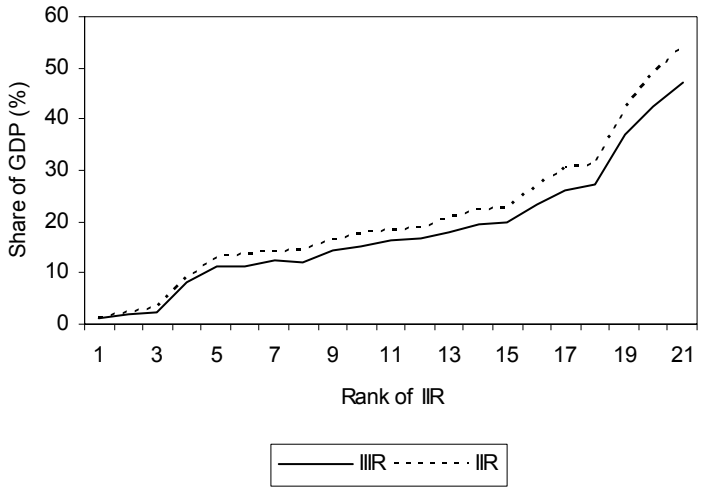
tic factors of production the exporting industries and their supplying industries need for production.

Thirdly, Figure 2 points out that the spread between the indicators IEDR and IER increases with the rank order. This spread reflects the imported intermediate products that a country demands to produce exports as a share of the gross domestic product. An increasing gap between the measure of total and actual openness reveals that a more open economy towards regional trade demands domestic factors of production at a relatively lower magnitude. For example, the more companies sell products on international markets, the more firms are confronted with the pressure to reduce costs and the more of them gain experience through exporting final products which let them include relatively more cost-efficient intermediate commodities from abroad than domestic production factors do.

Fourth, the curve of the IEDR index is less steep than the IER measure and, thus, the economies reveal smaller differences with respect to their degree of openness when the value-added based openness concept is applied. This implies that the importance of intra-regional trade is more similar for the countries within an integration area than the conventional approach suggests. Fifth, the jitter of the IEDR measure as well as the emergence of local maxima reflects that some positions of countries within the rank order change due to a shift in the indication of openness. The increasing importance of export-induced imported intermediates products disturbs the rank order.

Figure 3 completes the overview of Table 1. The diagram presents the values of the openness measures to intra-regional trade on the *import side* of the member countries of the EU, NAFTA, and MERCOSUR. The horizontal axis of the diagram puts the economies in increasing order of their IIR values. From its vertical axis, the empirical realizations of the IIIR and IIR index can be read off. The diagram discloses that the results of the actual openness concept for the import side correspond, in principle, to those of the traditional openness concept.

Figure 3: Actual and traditional openness on the import side, 1997 (percent of GDP)



Source: Own calculations based on GTAP (2003).

We now proceed to an econometric evaluation of the results via a brief regression analysis. For this purpose, we analyze the indicators of the traditional and actual openness concept with a *frequency distribution analysis* in Table 3. The standard statistical measures also include the Jarque-Bera test of a normality distribution (Jarque and Bera 1987). As usual, a small probability value leads to a rejection of the null hypothesis that the underlying distribution of the observations is a normal distribution. Given the whole picture, Table 3 confirms the previous outcomes.

Table 3: Frequency distribution analysis of openness, 1997

Sample 1 21 Observations 21	Export side		Import side	
	IEDR	IER	IIIR	IIR
Mean	14.01	20.98	18.31	20.95
Median	14.78	20.67	16.25	18.24
Maximum	29.28	50.59	47.33	54.12
Minimum	0.84	0.94	1.08	1.19
Range	28.44	49.65	46.25	52.93
Standard deviation	8.05	15.21	12.38	14.11
Variation coefficient	0.57	0.72	0.68	0.67
Skewness	0.17	0.77	0.83	0.83
Kurtosis	2.29	2.64	3.17	3.20
Jarque-Bera	0.54	2.19	2.42	2.47
Probability	0.7648	0.3340	0.2980	0.2907

Source: Own calculations based on GTAP (2003).

The results of the *correlation analysis*, as presented in Table 4, validate the first impression gained from Table 2 (rank orders of economies by their degrees of openness based on the traditional and actual openness concept). It characterizes the different rank orders of economies which are sorted by the traditional and actual openness concept. The analysis incorporates the rank order correlation measures developed by Spearman (ρ_R) and Kendall (τ), respectively (Kendall and Dickinson Gibbons 1990).

Table 4: Rank order correlation analysis of openness, 1997

Sample 1 21 Observations 21	IER	IIR
IEDR	0.990909 (ρ_R)	/
	0.952381 (τ)	/
IIIR	/	0.998701 (ρ_R)
	/	0.990476 (τ)

Source: Own calculations based on GTAP (2003).

The empirical realizations of the ρ_R and τ measure demonstrate that the positions of economies within the rank order do scarcely change when the new openness measure is applied instead of the conventional index. Exports include a larger share of imported intermediates the more an economy trades with other countries since, for example, experiences in exploiting cost-efficient input sources abroad increase. Positions on the import side alter even less than those at the export side or not at all, since the share of exported intermediate commodities in imports is of very low magnitude for the member states of the integration areas.

What additional insights between the relationship of bilateral trade and induced income can a *regression analysis* offer? It would appear that the following specifications of the regression equations are useful in our context:

$$\log \mathrm{IEDR}_t = \hat{c}_1 + \hat{c}_2 \log \mathrm{IER}_t + \hat{u}_t, \quad t = 1,2,\ldots,21 \text{ and} \tag{35}$$

$$\log \mathrm{IIIR}_t = \hat{c}_1 + \hat{c}_2 \log \mathrm{IIR}_t + \hat{u}_t, \quad t = 1,2,\ldots,21 \tag{36}$$

where the index t represents the economy with the number t in the sample. The estimator $\hat{c}_2$ in (35) measures the induced percentage change of IEDR_t when IER_t increases by one percent. Equation (36) has to be interpreted in an analogous fashion. We apply the ordinary least squares method after making sure that the usual assumptions of functionality, of no autocorrelation, normality and homoscedasticity of the residuals are valid for the chosen specifications. Table 5 displays the final estimation results.

Table 5: Regression analysis of openness, 1997

Sample 1 21 Observations 21	IER	IIR
IEDR	0. 87***	/
IIIR	/	1.00***

Source: Own calculations based on GTAP (2003).
Note: *** 1 percent significance level

The upper left-hand value of the table supports the result of Figure 2 that the importance of domestic production factors in relation to imported intermediate products to produce exports declines with the level of an economy's participation within the international division of labor. An increase of exports to the integration area in relation to all products for final demand (IER) of 1.0 percent increases the wealth at home for the same amount as the traditional concept suggests. But these exports only lead to an increase of 0.87 percent of the income that domestic production factors earn (IEDR). The value added of exports at home is lower because a part of the induced wealth is transferred abroad through the payment of imported intermediate products. As a consequence, the innovative value-added based openness method is

able to quantify the magnitude of the different sources of production inputs by taking production linkages in the exporting sectors and their supplying sectors into account.

For the import side, the regression analysis estimates an increase of the IIIR of 1.0 percent when the IIR raises 1.0 percent which the lower right-hand figure of the Table 5 indicates. This outcome clearly goes in line with that of Figure 3, namely that the share of exported intermediate commodities which are manufactured in the imports is at a similarly low level for the countries and hence independent of the degree of openness to bilateral trade.

4. Conclusions

The concept of trade openness is broadly applied as a potential predictor in numerous empirical studies, despite the fact that no commonly accepted approach of measuring openness has been developed. The most widely applied ('traditional') openness indices are not able to accurately calculate the degree of trade openness. For example, the intra-regional export ratio, which relates the value of exports to an integration area to the gross domestic product, can exceed 100 percent because trade is stated in gross terms, while the gross domestic product is expressed in value-added terms. This implies a negative value of domestic non-tradeables. Many openness concepts try to *adjust* the traditional measures of openness with an aim to increase the quality of indication, but most of these attempts show a poor correlation with the traditional concept. This might indicate that the alternative approaches capture different aspects of trade openness.

This study presents the development of innovative value-added based ('actual') measures of openness towards bilateral trade. They are based on a multi-regional input-output analysis of income effects due to trade. In clear contrast to the mainstream, the actual openness concept corrects the traditional concept by expressing trade in value-added terms instead of gross terms. All surveyed alternative openness approaches disregard the fact that the general inter-

pretation of the traditional concept is misleading. Traditional openness measures do not take the international redistribution of income generated by trade into account. This means, for example, that the intra-regional export ratio overstates the potency of a country to build a surplus in output at home because imported intermediate commodities that are employed in the process of production of exported commodities generate income abroad. The intra-regional import ratio, which expresses imports from an integration area as a share of the gross domestic product, overstates the dependency on imports since residents have to spend a lower portion of their income to purchase imports from abroad. Imports are partly produced with intermediate commodities delivered by the country that creates income for its production factors.

The innovative actual openness concept is able to reflect the different structures of production among countries since the value-added created by trade is forecasted on the foundation of a sound theory of production. This makes it possible to quantify the effects of the interdependences of industries within an economy. Open economies consist of more firms that import intermediate of final commodities for the purpose of their re-export than closed economies. These firms, which redistribute final commodities or process the finishing of imported intermediate commodities, employ less domestic factors of production and thus contribute less to national income than other firms which produce exports primarily with national intermediate commodities in all processing stages. This means that the more open economies are, the smaller the proportion of domestic production factors in the production process of exports is and the additional income earned from the selling of exports is again transferred abroad by means of imported intermediate commodities employed in exports. None of the approaches of openness measurement reviewed include this aspect of international trade.

The expression of trade in value-added terms, based on the theory of production, is an outstanding feature of the new actual openness concept, which is superior to the accuracy of traditional measures of indicating trade openness. In addition to this, the strong and statistically

significant positive correlation between degrees of openness calculated by the actual openness concept and those calculated by the traditional concept indicate that both approaches represent the same aspects of trade openness. Most of the alternative methods lack this feature.

Seen on the whole, thus, applications of our value-added based measures of openness might comprise the popular discussions about the quantitative importance of trade in and outsourcing of services, the significance of the label "export world champion" for a country like Germany, and - in a more general context - how far globalization has gone in the past.

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